

On the Dispersal of Seeds by Mammals.

BY

H. N. RIDLEY, M.A., F.L.S.

THE relations of animals to plants in the matter of fertilization has been the subject of many hundred papers and books written by various observers, especially since DARWIN published his well-known researches. But the various modifications and adaptations of the seed and fruit for distribution by animals, although of almost equal importance in the evolution of new forms, has been very much neglected. No one can avoid being struck by the observation that there are a very large number of plants in some orders, which closely resemble each other in the form and colouring of the flowers and yet differ very materially in the fruit. In many of these cases it is the necessity of special adaptation for dispersal of the seed that is the cause of the various modifications of the fruit or seed. Seeds are, as is well known, dispersed by the aid of animals, either by being swallowed by them and afterwards passed from the body at some distance from the parent plant, or by adhering to their fur or feathers and so being borne away, or by being thrown to a distance by them, as will be explained later on. Or again they may be dispersed by the aid of wind or water, being in the first instance blown far from the tree, and in the latter case being drifted away by sea or river currents; and lastly they may be scattered by merely mechanical means, as in the explosive capsules of the Castor-oil (*Ricinus communis*), and other Euphorbiaceous plants, or by merely rolling by their own weight when falling from the top of a lofty tree.

I may here call attention to a fact which has been overlooked by some naturalists in dealing with this subject, namely, that it is of no advantage to a plant to have its seeds borne to great distances but that on the contrary it may be positively injurious. In the first place the plants may be partially or wholly unisexual, the male and female flowers being on different trees. This is especially common among East Indian jungle trees, notably in the orders Euphorbiaceæ, Sapindaceæ, and Myristicaceæ.

Now if we suppose that a flock of pigeons have swooped down upon a nutmeg tree in fruit and swallowed a quantity of the seeds, and then flown away in all directions for, say, a hundred miles before passing the seed, the plants will eventually be at so great a distance apart, that it will be impossible for the flowers of the female trees to be fertilized, and such isolated trees can never reproduce themselves.

The same observation applies to plants which require a special fertilizing insect. If the seed is borne to a district where the fertilizer does not exist, it is to all intents and purposes destroyed. In this case, however, it is possible that another fertilizer may be found who can do the work fairly well, and indeed it is rare that any plant depends on a single species of fertilizer. And lastly there is always a risk of the seeds being deposited in an unsuitable locality, if borne too far away. This, however, is obviated by the conservative habits of the agents, thus fruit pigeons which always inhabit thick jungle, even if they did travel a long way with the seeds, inasmuch as they naturally fly to thick jungle, would almost certainly drop the seed in a locality similar to the one they took it from, and in the same way wading birds carrying seeds adhering to their feathers, would in their long migratory flights pass over jungles and deserts and only stop at pools or swamps where the seeds might get planted.

In the matter of wind-dispersed seeds also it is not difficult to show, especially in the flora of the big jungles, that travelling for a long distance is of no object and indeed does not seem to be aimed at. The object aimed at is rather to sprinkle the seeds at such a distance from the parent tree that the roots of

the latter may not interfere with the growth of the young plant, but not too widely to be absolutely isolated, nor on ground unsuited to the requirements of the species. It must be pointed out also that in the thick jungle where the foliage is very dense there is always a risk of the fruit when fallen resting in the branches, or in the tangled mass of creepers that mats together the branches of the big trees. It is, therefore, important that the fruits or seeds should be in many cases modified so as to avoid this accident. Besides in the case of such palms as *Pholidocarpus* and *Elaeis* where the stem is roughened by the projecting bases of the fallen leaves, there is always danger of the seeds resting in the spaces between these leaf bases and the trunk. This is usually obviated by the fruits being made edible and sought by birds, or mammals, as in the date-palms (*Phoenix*) or by the inflorescence being elongate so that the fruit is held out from the tree on long branches as in *Pholidocarpus*. The oil-palm (*Elaeis guineensis*) is not a native of Malaya, though often cultivated, and the spadix of fruit is short-stalked and hidden among the leaves, so that, unless some animal or bird devours the fruit, there is a great risk of the seed lodging among the leaf stalks, and as no bird here seems to care for the fruit, this is what often happens in trees in the Malay Peninsula. I have seen trees in the Botanic Gardens in which the spaces between the old leaf bases and the stem at the top of the trees were full of seedling oil-palms which, of course, would soon perish from want of nourishment.

In the Malay Peninsula, as elsewhere, the birds play the most important part in the dispersal of seed, but the mammals are agents also of considerable importance, and in this paper I intend to speak of their action in this work, and to compare it with that of the birds.

In the dense jungles that cover the hills of the Malay Peninsula one very soon notices that bird life gets scantier and scantier the further one penetrates them. Pigeons, hornbills and finches become scarcer, and almost entirely disappear, and even monkeys are not so abundant as one would expect.

In the woods of the Tahan valley in Pahang I have seen the

ground in some places strewn with fruits of various big trees absolutely untouched by animals or birds. In such spots the struggle for dispersal must be very great, and there must be a very large number of seeds wasted. Many trees and climbers in the dense jungle fruit very heavily and one frequently finds (especially where monkeys are absent) the ground beneath these plants almost carpeted with seedlings a short time after the fall of the fruit, but on visiting the same spot a few weeks later only a few of these young plants are to be seen. Nearly all have perished, partly from overcrowding and partly from absence of light. Nor does the waste of young plants end here, for a very large proportion of those that do become trees can never push their branches through the dense mass of older trees so as to be fully exposed to the light, when alone they can flower.

The contrast between the woods of the colder climates and the jungles of the tropics is most strongly brought out by the wonderful disproportion of species in a given area. In cold climates one frequently sees woods consisting almost exclusively of one species of tree such as the beechwoods of Southern England, and the firwoods of Norway, but in a Malay forest all the trees appear to be of different species.

Indeed it is only in exceptional places which are suited to a limited number of species (such a spot, for instance, as a mangrove swamp) that one sees a large number of individuals of one species together. In the jungles, which are suited to the requirements of a great variety of species, the different individuals are isolated, for here the ground is already so thickly covered with older trees and shrubs, that there are but few vacancies to be filled up. And thus of the immense number of seeds which fall from the trees, but few can find vacant spots on which they can develop into trees.

The assistance of the wind or of the mammals or birds which dwell in the forests is used to fill up these vacancies.

The plants which make use of animals to disperse their seeds either possess juicy or fleshy eatable fruits of which the seeds are passed through the bodies of the animals unhurt, or dry nuts, or again the fruits may be adhesive either by some viscid

material or by hooks or recurved bristles by which they adhere to the fur and are thus borne away.

The following are the mammalia of the Malay Peninsula which eat fruit, and probably all act to a certain extent, as some do to a very large extent, as seed dispersers:—

Quadrumana:—*Hylobates* (Wau-Wau), two species; *Semnopithecus* (Lotong), one or more; *Macacus*, two or three species; Chiroptera (bats); *Pteropus* (Fruit-bats), two or more species. Insectivora:—*Tupaia*, several. Carnivora:—*Viverra* (civetcats), several species; *Arctictis* (Binturong) and probably *Hemigale*; the bear *Helarctos malayanus*; Rodentia *Sciurus* (Squirrels), several; *Sciuropterus* (Flying Squirrels), *Mus* (Mice and Rats), probably several. In addition to these must be added the deer, the wild pig (*Sus indicus*), the elephant, and probably the wild ox (*Bos gaurus*) and the buffalo (*Bubalus arnee*), which disperse seeds of grasses and other herbaceous plants both by swallowing seeds in the herbage they eat, and by bearing, attached to their skins, the adhesive fruits and seeds.

Quadrumana.—The monkeys haunt the big jungles wandering about in small flocks and avoiding the open country. They live chiefly on fruit, and of these they generally attack the juicy or succulent kinds, although they will occasionally eat the chestnuts and other dry fruits. The commonest species in Singapore is the Kra (*Macacus cynomolgus*) and this is one of the most important of the seed-dispersing mammals. The fruits I have chiefly seen it devouring are those of various species of *Eugenia*, *Baccaurea*, *Mangifera*, *Willughbeia*, *Dialium*, *Trichosanthes*, *Nephelium*, *Careya*, *Strychnos*, *Eleocarpus*, *Randia*, *Calophyllum*, *Gardenia*. And here I will point out that the fruits eaten by mammals are usually plain green in colour and inconspicuous, and frequently of considerable size, whereas those which are intended for dispersal by birds are often scarlet, orange or yellow, more rarely blue or white and small. The reasons for this are, that the mammals move comparatively slowly through the jungle searching the fruit close at hand, for it is impossible for them to see far into the thick mass of foliage, whereas the birds moving more

rapidly and at a higher elevation can detect fruit, if coloured, at a great distance and can speedily make their way to it, and that besides many of the fruit-eating mammals are nocturnal and, therefore, colour would be useless to them in the dark.

Berries and drupes are eaten whole (except for the skin) by the monkeys, if they are small, like *Nephelium*, *Zizyphus*. In these fruits the sweet pulp often adheres strongly to the stone making it so slippery that it is almost impossible to avoid swallowing the latter. *Zizyphus calophyllus*, a common creeper with small globose fruit, and the Mata-kuching (*Nephelium malaiense*) are good instances of this form of drupe. In *Baccaurea motleyana*, Hook, the Rambai, the seeds, of which there are three in a fruit inclosed in sweet pulp, are very thin, and are quite troublesome to eject.

The Malays and the Sakais in eating these fruits generally swallow the seeds even of such large drupes as the Rambutan, and I have seen in the deserted encampments of the Sakais in Pahang germinating seeds of the Rambutan which had been swallowed and had passed through their bodies. The Malays indeed say that this is the most wholesome and pleasant way of eating these fruits.

There are two forms of the fruit of the Polessan (*Nephelium mutabile*), in one of which the flesh adheres tightly to the stone, and in the other it is firmer, and readily breaks away, and can be nibbled off easily. If a monkey ate the cling-stone variety the seed would slip down its throat, while from the firmer-fleshed free-stone variety it would nibble the flesh and throw the stone away. In drupes of this kind it is essential that they should not be too large for an animal to swallow, and there is a decided advantage in the sweet pulp being very thin as it is thus more slippery and cannot be detached by biting. Many large and heavy fruits like those of the wild mangoes (*Mangifera cæsia*, *lagenifera*, etc.) and *Careya* are carried by the monkeys who gather them to a convenient perch to be eaten, and in doing so they frequently drop them, so that one finds large fruits partially eaten often at considerable distances from the parent tree. But the weight of these fruits has also another advantage, by preventing their lodging in the tangled

mass of creepers and thick foliage which often mats the tops of the highest trees together, and causing them to fall and roll to some distance.

The *Willughbeias* are lofty climbers in the jungles. They have large dull green or yellowish inconspicuous fruits, pear-shaped or globose. The seeds are soft and enclosed in a sweet and eatable flesh, of which the monkeys are very fond. There are a number of seeds in a single fruit, and if, as sometimes happens, the fruit falls whole on the ground the seeds all germinate in the fruit, so that one finds a small cluster of plants where a fruit has fallen and decayed. After these have grown a few inches, all or nearly all perish from overcrowding, and in localities where monkeys are scarce I have seen the ground covered in places with seedlings, of which in a few weeks none are left. If, however, a flock of monkeys visits the locality when the plant is in fruit, all the best fruits are speedily devoured. Monkeys like other mammals are very greedy eaters, and when there is plenty of fruit on a *Willughbeia*, they do not entirely finish each fruit, but tear it to bits and scatter the seeds in different directions, only eating bits of it. The seeds of the *Willughbeia* are soft and comparatively tasteless, or if they have a flavour it is bitter and unpleasant, but a great many do get bitten up and destroyed by the monkeys, even if a considerable number are detached and scattered about, unharmed.

It has been pointed out to me that *Willughbeia* seed to be satisfactorily planted must be thrown at the base of or near a big tree so that the creeper may have a support to climb on, and this is brought about in the following way. A monkey seizes a fine fruit to eat, the others of the flock immediately rush at him to take it away, he scrambles into the nearest big tree and getting into the fork or behind a big branch devours it with hurried bites for fear of being robbed, throwing the seeds at the foot of the tree up which the young plant can eventually climb.

Nearly all the *Willughbeias* and the plants of the allied genera *Melodinus* and *Leuconotis* are climbers in thick jungle, and in this case the fruits are, as above said, green, or at most

tinted a little with yellow or orange. Those, however, that grow in more open country or on the exposed edges of jungles have bright yellow or orange coloured fruits.

In the heathy country bordering the Pahang River, I found a species of *Willughbeia* which bore exceedingly pleasant, small, oval fruits of a bright apricot-yellow colour and very conspicuous. It grew in low thickets in open sandy country, where monkeys do not go, as they have an objection to travelling far on the ground on account of the risks from tigers, wild cats, dogs and other enemies. The conspicuous fruited *Willughbeia* had probably developed its showy colour to attract birds, of which there were many large fruit-eating kinds, and the reduction in size of this fruit is also an assistance in dispersal as even the hornbill can hardly manage to carry a globose fruit as large as that of *Willughbeia edulis*.

The various species of *Dialium*, known to the natives as Kranji, are big trees with ovoid black pods, each containing one hard seed which is enclosed in a somewhat acid but pleasantly flavoured pithy substance. The monkeys are very fond of these and one often sees the remains of the fruit on the ground. The fruit is unfortunately relished by the monkeys before it is ripe so that very often the whole crop is gathered green by them and so destroyed, and here I may call attention to the value of acidity of unripe fruits in preventing animals from eating them too soon, which would soon exterminate the trees by destroying the seeds.

Though many of the fruits eaten by animals are sweet or pleasant to our taste, a large proportion of those very popular with monkeys are either tasteless or nauseous—often astringent in flavour to us. Some may even be poisonous as *Strychnos*.

Cheiroptera.—There are several kinds of fruit-eating bats in the Malay Peninsula, but of their habits little is known. The largest kind, *Pteropus edulis*, is very irregular in its appearance. In some years there are hardly any to be seen in Singapore, but some years ago there were enormous numbers roosting every day in the Garden jungle. They fly great distances and may be seen far out at sea. They eat great quantities of fruit of different kinds. *Cynopterus marginatus*

is a small and very common species which during the day hides in the leaves of plantains, or palms, or, when it can, in caves. It eats fruits voraciously, especially figs (*Ficus Miquelii* and *Benyamina*), and I have seen it, or allied species, in great numbers at the Tembusu tree (*Fagrea fragrans*), *Livistona australis*, the *Nepheliums*, the Chiko (*Achras sapota*) and other trees.

It is difficult to see how these animals detect the fruit on the trees in the night, but perhaps they use the powers of smell. In any case it must be easier for them to find the fruits than for the insectivorous bats to see and catch insects at night. It appears to me that fruit-eating bats are much less intelligent than the insectivorous kinds. They are slower in flight and more constantly caught in house at night being utterly confused by the light, whereas insectivorous bats fly readily in and out.

The Malays keep these animals off from the fruit trees by attaching to the boughs the thorny *flagella* of the rattans which are collected and sold for this purpose, so that the bats in flying to the fruit get their wings entangled and torn by the thorns.

Viverridæ.—Of the greater number of the species of this group little or nothing is known as to their habits. All appear to be omnivorous, and certainly eat a very large quantity of fruit. They are nocturnal and find the fruit probably by the scent. The common civet cat or Musang (*Viverra malaccensis*) is a most destructive eater of cultivated fruit.

I have seen in its excreta the seeds of coffee, *Gnetum scandens*, *Caryota Cumingii* *Mimusops elengi*, and it is also very partial to the fruits of *Artocarpus rigida* and *integrifolia* (the Jack), *Diospyros discolor*, *Achras sapota*, and many other fruits.

Its habits of selecting the best coffee berries to eat is well known to planters, who often collect the seeds passed by the Musangs for cultivation, as giving stronger plants. It has a habit of dropping its excreta on open spaces, especially paths, so that the seeds passed by it can very readily grow.

The Binturong (*Arctictis binturong*) lives much on fruit.

One kept in captivity ate papayas (*Carica papaya*) and Rambais (*Baccaurea motleyana*, Hook.) swallowing the seeds and passing them apparently uninjured.

Ursidæ.—The common bear (*Helarctos malayanus*) is a nocturnal fruit-eater, and is particularly found of Durians. The fruit of the common Durian (*Durio zibethinus*) when ripe falls entire upon the ground, and when found by the bear, is torn to pieces and the seeds scattered about. The bear, however, also ascends the tree as well and helps itself to the Durians, which grow, as is well known, on the thick branches, where it can get at them.

In the wild Durian (*D. Oxleyanus*) the fruit splits on the tree and lets the seeds fall. In one wild Durian which I saw at Pekan, the flesh of the seed was pink and the capsule split so as to show the bright colour. It grew in a part of the country where there were no bears and was probably dispersed by some such bird as the hornbill.

I gave a bear a wild Durian (*Durio oblongus*) to eat. It tore it to bits with its paws and ate the aril of the seed and a good deal of the placentas, but would not eat the seed and spit it out so that it fell some way off. Another bear seeing the seed fall bit it, but did not like the taste and would not eat it. There was no particular taste to the part that the bear ate, though it was very eager to eat it, nor had the rejected seeds any taste that seemed objectionable to me.

I will here digress a little to compare the several forms of fruit of the *Durioneæ* showing their various modifications and their meaning with respect to dispersal.

In the genus *Durio*, the fruit is a thorny capsule, dull brown or green, and the seeds have a white or pink edible aril.

Durio zibethinus, L. The fruits are borne on the strong branches, on short stalks, and are strongly scented so as to be easily found at night, and are dispersed by the bear, a heavy nocturnal animal.

D. oblongus, Mast. The fruits resemble those of *zibethinus*, but are not scented. They open on the tree, and eventually drop the seed. They are probably dispersed by birds, as the

plant is a native of Singapore where there are no bears.

D. sp. has a scentless fruit with a conspicuous red aril on the seeds. There were no bears in the locality, so that it was probably dispersed by hornbills, which were abundant.

D. testudinarum, Becc., has the fruit at the base of tree. This is called Durian Karkura (Tortoise Durian) in Borneo by the natives, according to BECCARI, and is perhaps eaten by these animals.

Neesia synandra, Mast. This has a very hard woody capsule, bluish grey, not or hardly armed. Seed black, with a small yellow waxy aril. The fruit drops whole, and the seeds are protected till ripe by a quantity of pungent irritating yellow bristles lining the inner walls of the woody capsule. The aril and sometimes the whole seed is eaten by mice. (The seed falls out of the capsule when the capsule falls.)

Cælostegia Griffithii, Mast., has a very large rather round capsule covered with thorns, and of a showy orange colour. The seeds are chesnut colour and conspicuous, with an orange waxy aril. They do not fall out of the fruit, but fall with it. I imagine that they are dispersed by the agency of birds but I found rats very partial to them.

Boschia Griffithii, Mast., a very small Durian with a conspicuous scarlet capsule, splitting on the tree, and exposing the black conspicuous seeds. The form and colouring of this remind one of the fruits of *Sterculia lewis* which is dispersed by birds. The fruits are borne on small twigs, and I have little doubt but that the seeds are scattered by birds. BECCARI gives Durian Tupai as one of the native names of the plant in Borneo, this would mean Squirrel Durian, but does not imply that squirrels eat it, *tupai* being really equivalent to *tikus* (mouse) meaning of small size, as opposed to *gajah* (elephant) which means in speaking of fruit, &c. large. Thus *Commersonia platyphylla* anders is called in Singapore Durian Tupai because the fruit looks more or less like a very small Durian.

Insectivora.—*Tupaia ferruginea* and other allied species although belonging to the order Insectivora are chiefly frugivorous. They appear to eat the smaller fruits such as those of

Marlea nobilis and *Eugenias* which have a firm texture and are not very hard.

Ungulata.—The Ungulates of the Malay Peninsula include the elephant; rhinoceros, one or two species; tapir, wild ox (*Bos gaurus*); deer, one or two species; mouse deer, two or more species; and the wild pig. To which must be added as a seed disperser the buffalo (*Babalus arnee*). These animals act more as scatterers of seed attached to their hair or hides, but probably also, to a certain extent, by swallowing grass-seeds in the herbage. The first four are inhabitants of the densest jungles, especially of the hill regions, and feed chiefly on the bushes and leaves of trees. They make long tracks through the dense forests, and wander often to great distances. I have seen many seedlings, apparently of some small herb, springing up in dung of elephants dropped in their tracks. The wild ox lives, to a small extent, on fruit. One brought down to Singapore ate greedily the fruits of the Sentol (*Sandoricum indicum*).

Scoparia dulcis L., is a small herb introduced accidentally from South America which has been widely scattered by the water buffalo. In Pahang, I traced it up the Pahang and Tembeling Rivers as far as the buffalo went. On sandbanks in the river where for some reason buffaloes had not gone this plant was absent, and I saw it and also *Cleome viscosa* springing from masses of buffalo-dung, in several places. Many of the smaller herbs and especially grasses and sedges must be distributed by this animal in this way, and *Fimbristylis miliacea*, a sedge very abundant in marshes where these animals go is called by the Malays *Rumput Tahi Kerbau* (buffalo's dung grass) for this reason.

Rodentia.—The important seed distributors in the family are the rats and the squirrels.

The rats and mice of the Malay Peninsula are as yet very little known. I have seen at the foot of Mount Ophir, in dense jungle by a stream, a large reddish rat eating the fallen fruit of a wild species of mango, of which it might easily have borne off fruits to its holes under the boulders to some distance from the tree.

There are a great number of herbaceous plants, the fruits

of which are more or less concealed among the leaves or in the ground. Such is *Curculigo sumatrana* which has small inconspicuous sweet fruits with very small seeds. These disappear as soon as ripe, and are certainly eaten by some rodent. The *Scitamineeæ* again have fruits which are much sought by these little animals. Most of the jungle loving species have the fruits at the base of the stems as *Amomum*, *Zingiber*.

The fruits are inconspicuous, but in many cases the bracts which enclose them are red. This colouring, however, bears rather a relation to the floral stage of development and is intended to make the flowers more conspicuous to the insect fertilizer. When the plant is in fruit, the bracts have usually become shabby and inconspicuous.

Nicolaia hemisphærica and *Amomum laterale* are two species which have plain green fruits, in the former in a head on a short, stout stem, in the latter in a stout, cylindric, lateral spike about a foot above the ground. These fruits are devoured by some rodent (probably a squirrel) as soon as they are ripe.

There is a great contrast between the fruits of these jungle gingers where the inflorescence is a compact head and radical or low down, and those which live in more open country and possess terminal inflorescence. In the former the fruits are inconspicuous and often green, while in the latter they are either showy and orange as in the *Alpinias* of the river banks, or they are white in the plants of the open jungle as in the case of *Clinogyne* and *Alpinia galanga*.

The squirrels (*Sciurus*) probably disperse more seeds than the *Muridæ*, and being diurnal can more easily be seen at work. They do not, as a rule, eat sweet or juicy fruits, but those of firmer texture, as those of the Daroo (*Sideroxylon sundaicum*), *Marlea nobilis*, and *Pyrenaria acuminata*. All these are inconspicuous, small, green fruits containing hard seeds, and it is very common to find gnawn fruits lying some way off from the trees, usually with the seeds uninjured. In many cases a tree is completely denuded of fruit as fast as it is ripe, and the squirrels carry it so far that it is impossible to find any. To some of the introduced fruits they are very

destructive especially to cocoa (*Theobroma cacao*) and to coco-nuts, destroying the latter by biting round holes into the fruit and eating the interior, so that trees near jungle, if unprotected, lose all their fruits.

But it is on the fruits of oaks and chestnuts that these animals chiefly live. These trees fruit very heavily, more so than any class of tree here, and the ground beneath an oak in fruit is often covered with acorns. The chestnuts (*Castanopsis*) nearly all have their fruit arranged in close spikes and usually covered with a prickly involucre. The whole spike readily breaks off the tree, but it is difficult to separate the individual chestnuts. A squirrel seizes a spike and breaks it off, and holding it in its paws attempts to nibble through the prickly husk to eat the fruit and it often happens that owing to the prickles being too sharp for it, it drops the whole spike before it has succeeded in eating more than one nut.

The squirrels invariably, if possible, when they have gathered one of these fruits run to a short distance to eat it conveniently, so that the nut or acorn may be carried to some distance before it is dropped. The big *Sciurus bicolor* is an entirely arboreal squirrel living in very dense jungle and very rarely if ever coming down to the ground, and when it takes a fruit it runs to a suitable spot to devour it. It sits transversely on the bough, holding on with its hind feet, its head and forearms hanging down over the bough on one side and its tail on the other. In this position it is very likely to drop a nut either too prickly or too smooth for it to hold fast. The smaller squirrels (*Sc. notatus* and *Sc. tenuis*) when they descend the trees to pick up the fallen acorns or chestnuts, which *Sc. bicolor* never does, always run up an adjacent tree to eat them, and I have frequently seen one carry an acorn in its mouth for some distance before eating it. I recently saw a small red-bellied squirrel (*Sc. notatus*) eating the fruits of an *Eleocarpus*. When it took a fruit, it hung head downward from a bough by its hind feet only. *Sc. tenuis* too usually hangs from the trunk of a tree by its hind feet head downwards when eating acorns. As there is no season here when a squirrel cannot get food, it never stores up

seeds in holes as the English squirrel does for the winter. Among the oaks, which are more abundant than the chestnuts, there seems at first sight even less protection for the seed or means for its dispersal than for the latter, but there are certain slight modifications which have a most important effect in these matters. The acorn is nearly always quite exposed, and the cup, which corresponds to the involucre of the chestnut, is not armed, although in some species it is roughened with soft hooks (*Quercus hystrix*).

If one examines the acorns which have fallen from a tree where there are many squirrels, one notices that they are all nibbled at the base, and there are often marks of teeth as of ineffectual bites on the sides. I gave a *Sciurus bicolor* some acorns of *Quercus lucida*, a large rounded acorn with a thick but shallow cup. Taking them between its paws, it made an attempt to bite into the side of the acorn, but the outer coat was so smooth that its teeth slipped and it could not get a hold. It then turned the acorn round and bit the cup, and the acorn immediately fell out of the cup and rolled away. Had it been up in a tree when it tried to eat the acorn, the fruit would have fallen down and rolled perhaps far from the parent tree. On giving it the acorn again it began to bite the rim at its base, but it was clear that the smooth polished surface of the fruit was too slippery for its paws, and even on the floor of its cage it had some trouble in holding it.

Many of the acorns have a fairly firm outer coat thus polished, and fall very readily from the cup when ripe, but some such as *Q. encleisocarpa*, and *Q. Cantleyi*, two of our commonest species, have an improvement on this. The acorn is coated with a very fine silk, which has almost a greasy feel. It is not at all easy for a squirrel to hold these in its paws to eat, and it is very common to see the acorns of the former scattered all over a wood in which there is a tree in fruit, and nearly all of these bear the marks of squirrels' teeth, but for all practical purposes are unhurt. *Q. encleisocarpa* has the cup in the form of a thin brown covering, from which, though it is much cracked and split when ripe, the acorn never falls. In *Q. Cantleyi* the acorn is readily detached

from its cup and is most difficult for a squirrel to hold. It can take it in its mouth by the aid of the raised circular rim at the bottom and thus carry it off, but to eat it it must hold the slippery conical portion in its paws so as to nibble at the base, the only place where its teeth can get a purchase, and it naturally lets many of these silky-coated acorns slip unhurt from its grasp.

The method of dispersal is a very expensive one, a large proportion of seeds being destroyed by the squirrels, compared with those that are deposited by them in suitable positions for development into trees, but so large is the crop produced at one time that the number safely planted is quite sufficient to keep up the stock. It must be remembered too that it is necessary for the trees to supply enough nuts to tempt the squirrels. If the squirrels did not get enough off the trees to eat or these seeds were so well protected that they could not get at them, they would be less likely to visit the trees at all and indeed where there are few or no squirrels, as in the hill forests, oaks and chestnuts are much more scanty than in the low country where they abound.

WALLACE (*Tropical Nature*, ed. 1891, p. 400,) says of most of the plants whose large seeded nuts cannot be eaten without destroying their germinating power:—"It is a suggestive fact that they are among the most ancient of known dicotyledonous plants—oaks and beeches going back to the cretaceous period with little change of type so that it is not improbable that they are older than any fruit-eating mammal adapted to feed upon their fruits."

Still in the prickly husk of the chestnut, and in the smooth polished or silky exterior of the acorns, we see that these fruits have undergone modifications by which the little enemies have been prevented from exterminating the trees, and have been utilized as dispersers of the seeds.

Very much remains to be observed still as to the action of fruit-eating mammalia as seed-dispersers. Many of them are difficult to watch in a wild state on account of their shyness and nocturnal habits, and even in Malaya there are several such as the Loris (*Nycticebus tardigradus*), the Galago

(*Galeopithecus volans*) (which, however, certainly lives very largely and possibly altogether on leaves), the Binturong (*Arctictis*), the larger *Viverras*, *Hemigale*, *Paradoxurus*, and the fruit-bats, of the habits of which in wild state little or nothing is known. But I think it may be noticed that the fruits especially sought by mammals are inconspicuous and dull-coloured and not brilliant. This, however, must not be held to imply that bright colours are not visible to the diurnal mammals such as monkeys. Sir JOHN LUBBOCK has used the argument of the coloured fruits forming the food of monkeys against the theory of MAGNUS, GEIGER and GLADSTONE that the ancients were colour blind, saying that "if monkeys and apes could distinguish colours surely we may infer that even the most savage of men could do so too." (Flowers, Fruits and leaves, p. 74.) There is, however, no doubt on other grounds, notably the brilliant colours of the males of some monkeys themselves, that monkeys are not colour blind, while the fact that the Malays have fewer names for colours than they can see, and the Pahang Sakais, as Mr. CLIFFORD has shown in the last number of the Journal, have only three names for colours—black, white and red—although they can apparently distinguish others, entirely negatives the colour-blind theories, which are but another example of the worthlessness of ethnological deductions based on the study of ancient literature only, unsupplemented by comparison with the characteristics of modern savages.

List of plants, the seeds of which are certainly dispersed by mammals.

Adinandra dumosa. Fruit white, with small seeds. Eaten by bats.

Durio zibethinus, L. By bears.

Neesia synandra Mast. Seeds with eatably yellow aril. Mice.

Canarium rufum and other species. Fruits green or dull purple with a turpentiney or sweet taste. Eaten by monkeys. A single large seed protected by an excessively hard shell.

Calophyllum pulcherrimum and other small fruited kinds

Fruits green with a hard seed. Bats and monkeys.

Elæocarpus. Fruit green or blue. Stone hard. Monkeys.

Pyrenaria. Fruit green. Seeds hard. Monkeys, squirrels.

Parinarium Griffithii, Hook. Fruits firm dull purplish. A large hard seed. Monkeys.

Strombosia javanica, Bl. Fruit green. Stone hard. Squirrels.

Mangifera. Fruit green, yellowish or grey, large. Stone hard. Rats.

Nephelium. Mostly dull coloured. Civets, monkeys, bats.

Xerospermum. Fruit yellow. do.

Lansium domesticum, Jack. *Langsat*. Fruit whitish. Seed covered with sweet pulp. Civets.

Dialium. Fruit black. Seeds hard. Monkeys.

Eugenia grandis, Willd. Fruit green. Stone hard. Monkeys, squirrels.

E. scoparia, Wall. Fruit blue. Stone hard. Monkeys, squirrels.

E. malaccensis, L. Pink or white. Stone hard. Monkeys, civets.

Careya arborea. Large green fruits. Monkeys.

Psidium guava, L. Fruit green. Seeds small and hard. Civets.

Barringtonia racemosa. Fruits modified for sea-travelling, but I have seen a squirrel run off with one to some distance. They are dull green with a large stone.

Melothria, *Mukia* and other small terrestrial *Cucurbitaceæ*. Fruits usually dull green. With many hard seeds. Eaten by rats.

Marlea nobilis, C. B. Clarke. Fruits green, hard stone. Squirrel, tupaia.

Citrus aurantium, L. Fruit orange, usually green when ripe in the tropics. Monkeys, civets (Opossum in Brazil).

Coffea. Berries red. Seeds hard enclosed in a thin sweet pulp. Civets, monkeys.

Gardenia Griffithii, Hook. Capsule green, full of flat seeds in a sweet pulp. Monkeys.

Randia anisophylla, Do. do.

Dichopsis obovata, C. B. Clarke. Fruit green passing into orange. Seed hard. Monkeys.

Sideroxylon sundaicum. Fruit green. Seed hard, polished. Squirrels.

Mimusops elengi, L. Fruit orange. Civets (also birds).

Achras sapota, L. Fruit brown. Seed hard, polished. Civets, bats.

Diospyros discolor. Fruit pink, dull and inconspicuous. Scented Civets.

Willughbeia. Fruit green. Monkeys.

Strychnos Tiente. Fruit green. Seeds poisonous, imbedded in a sweet pulp. Monkeys.

Fagraea fragrans. Fruit orange. Usually eaten by birds, but also by bats.

Baccaurea Motleyana, Hook. Fruit white. Monkeys, squirrels.

Laurinea sp. Small inconspicuous, green fruit. Hard seed. Monkeys.

Artocarpus rigida, Bl. Yellow. Fruits large yellow, inconspicuous. Seeds small enclosed in a sweet orange pulp. Civets.

Ficus (Figs). Inconspicuous fruited kinds, e.g., *F. Miquelii* *F. Benjamina*. Bats, also more rarely monkeys and also birds.

Quercus, *Castanopsis*. Fruit inconspicuous. Squirrels, more rarely monkeys.

Gnetum scandens, Bl. Fruit orange. Hard seed. Civets.

Anomum. Fruit usually inconspicuous, Squirrels, rats.

Zingiber. Do. do.

Musa. Wild plantain. Fruit green, inconspicuous. Seeds small, hard. Monkeys.

Curculigo. Fruit inconspicuous, hidden. Probably eaten by mice.

Livistona. Fruit black. Seed large hard. Bats.

Caryota. Fruit dark red. Seed hard. Civets.

Zalacca. Fruit brown, acid. Seed large hard. Rats or squirrels.

Calami. Fruit brown or yellow. Seed hard, covered with thin pulp. Apparently eaten by squirrels, very speedily taken, the nibbled skin only left.

Scirpodendron. This aberrant *Sedge* has its inconspicuous fruits always nibbled by some small mammal.

ADHESIVE FRUITS DISTRIBUTED BY MAMMALS

In the Malay Peninsula there are fewer plants furnished with means of adhesion to fur or feather than in many parts of the world. This is owing to the limited amount of open country, the greater part of this region being covered thickly with a dense jungle of lofty trees. For the greater part of the adhesive fruits belong to herbs, or half-shrubby plants living in flat, open country. Of such as we do find here, a number are aliens more or less accidentally introduced, such are the white Plumbago (*Plumbago zeylanica*, L.), *Urena lobata*, the sensitive plant (*Mimosa pudica*, L.), *Triumfetta*, and *Paspalum conjugatum*, L. Nearly all of these are carried about by man or domestic animals.

In *Plumbago zeylanica*, L. the calyx which encloses the capsule is provided with sticky hairs, which readily adhere to clothes or fur. The plant is common in villages, but I never saw it at any distance from cultivation. In *Triumfetta*, a roadside weed, the capsule is provided with hooks.

Paspalum conjugatum is a common grass, the very small spikelets of which are rounded and edged with short, bristly hairs. They are very easily detached from the rachis on which they are arranged, and attach themselves readily especially in wet weather to clothes, &c. This grass has travelled further than any of the introduced weeds throughout the Peninsula. I have found it growing in crevices of rocks in the Tahan River as far as I have been, and on Padang Batu on Mount Ophir, I saw a plant growing at the stream close to the camping ground, at the spot where the natives who visit the spot are accustomed to bathe and wash their clothes. A very long way from the flat country where it is abundant.

In *Chrysopogon aciculatus*, Beauv., commonly known here as love-grass, the spikelets are arranged in an erect panicle with slender, wiry branches each of which bears one fertile spikelet the base and one or more barren spikelets. From the

bottom of the lowest spikelet projects a spur covered except on one side with stiff yellow hairs pointing upwards. When the fruit is ripe this fertile spikelet readily breaks off and adheres by its spur to cloth or the fur of an animal and is borne away. This grass is very abundant in dry open country, and forms an extensive turf in many places.

Besides these grasses, there are three species which inhabit the dense jungles, and excepting bamboos, are the only jungle grasses here. They are *Leptaspis urceolata*, Br., *Lophatherum gracile*, Brngn., and *Centotheca lappacea*, Beauv.

The first of these has a loose spreading panicle bearing curious oval spikelets, of which one of the outer glumes is, in the female flower, swollen up and entirely encloses the fruit, this outer glume is covered thickly with short but strong, abruptly hooked hairs, by which it clings very tightly to a passing animal. So adhesive is it that in brushing past it it often happens that the whole inflorescence is torn off.

In an allied species *L. cochleata*, a native of Ceylon, the spikelet is smaller and kidney-shaped with five ridges and covered in like manner with very short hooked hairs.

In *Lophatherum* the spikelets have several glumes, of which the eight terminal ones bear awns covered thickly with minute processes pointing downwards. When the fruit is ripe the awns become hooked by drying, and by this and the minute processes the spikelets can attach themselves to any animal.

In *Centotheca* not only are the branches of the panicle provided with short processes (pointing upward in this plant) but from each side of one of the upper glumes which encloses the fruit, project a double row of long, white processes by which means the whole panicle readily adheres to the clothes of man or to the fur of an animal. These two latter grasses are especially common along paths and animal tracks in the thickest jungles, but where it is too thick for animals to go easily one does not find them.

It is probable that more plants will be found which possess these adhesive fruits in the Malay Peninsula, but these will, I think, be chiefly introduced weeds. In any case the number will be very much smaller than that of plants dispersed in any

other of the ways mentioned above, viz., by being swallowed by animals or birds, or being drifted by wind or water.

The part played by mammals is insignificant compared with that played by birds in the dispersal of seeds, but as has been shewn it is too important to be overlooked.

Of the great waves of evolution which in past times have altered the whole character of the Flora of the world, the first and greatest was probably that due to the appearance of pollen- and honey-seeking insects through whose agency the brilliant colours and elaborate forms of flowers were evolved. The next was due to the evolution of the frugivorous birds through whom we have obtained much of the colouring and sweetness of the fruits. Through the evolution of mammals, we have also obtained many modifications of fruits, and the development of some groups of plant, notably the grasses and some of the other herbaceous plants will, I believe, be eventually shown to have borne a close relation to the evolution of the graminivorous mammals so abundant at one period of the world's history.